POLITECNICO DI TORINO
Repository ISTITUZIONALE

Knowledge spillovers, green entrepreneurship and the demand for sustainability: evidence from Italian innovative startups

Original
Knowledge spillovers, green entrepreneurship and the demand for sustainability: evidence from Italian innovative startups / Colombelli, A., D'Ambrosio, A., Le Masle, B., Ravetti, C., Tubiana, M.. - In: THE JOURNAL OF TECHNOLOGY TRANSFER. - ISSN 0892-9912. - (2026). [10.1007/s10961-025-10224-8]

Availability:
This version is available at: 11583/2997927 since: 2025-02-27T01:40:26Z

Publisher:
Springer

Published
DOI:10.1007/s10961-025-10224-8

Terms of use:

This article is made available under terms and conditions as specified in the corresponding bibliographic description in the repository

Publisher copyright

(Article begins on next page)

08 November 2026

Knowledge spillovers, green entrepreneurship and the demand for sustainability: Evidence from Italian innovative startups

Journal of Technology Transfer
(accepted version)

Alessandra Colombelli[*], Anna D'Ambrosio[*], Baptiste Le Masle[**], Chiara Ravetti[*], Matteo Tubiana[*]

[*]Politecnico di Torino [**]Université de Strasbourg

Abstract

Investigating the relationship between knowledge dynamics and the local demand for environmental sustainability can provide new insights into the forces behind the emergence of innovative green entrepreneurship. We explore the interplay between knowledge availability and green innovation in a territory within the Knowledge Spillover Theory of Entrepreneurship (KSTE) and expand the KSTE by integrating demand-side factors. We test how the creation of innovative green ventures correlates with the match between the size and composition of the knowledge stock and local green demand, proxied by measures of pro-environmental behaviours. We identify green startups from the Italian Registry of Innovative Startups with a novel AI-based methodology that performs unsupervised topic modelling on text from companies' websites. This machine-learning algorithm detects companies' alignment with environmental Sustainable Development Goals (SDGs). We then perform a province-level econometric analysis to examine the interaction between the (green) knowledge stocks, demand factors, and the creation of green startups. Our findings confirm that local demand for environmental sustainability is associated with innovative green startup creation and magnifies local knowledge stocks' role. Interestingly, we show that green entrepreneurship is more strongly related to the local knowledge stock's size than its "greenness".

Keywords: knowledge spillovers; innovative startups; green entrepreneurship; environmental sustainability; local green demand

JEL codes: L26; O31, Q56

Acknowledgements: We thank Stefano Bianchini for the valuable discussions on AI algorithms for natural language processing, which led to our choosen method to identify green startups, and Francesco Quatraro for providing province-level data on green patent applications. We are grateful to Ekaterina Prytkova and the participants at the Knowledge Dynamics, Industry Evolution, Economic Development (KID) 2024 Conference for comments and feedback on an early version of this work. We thank Al Link and the participants of the workshop "Networking event in honor of Distinguished Professor Al Link", as well as anonymous reviewers and guest editors of the special issue for helpful suggestions that improved earlier versions of this manuscript. All usual disclaimers apply.

1. Introduction

Green innovative startups are ascending in policymakers' priorities because they can bring to the market innovative technologies that simultaneously contribute to economic growth and promote a sustainable and eco-friendly future (Horne & Fichter, 2022). Startups are the primary drivers of "green" market innovation, introducing new ideas and inventions that might transform entire industries (Fichter et al., 2023). For this reason, green startups with a highly innovative profile are central to achieving the green transition (Abdesselam et al., 2024).

Classic entrepreneurial frameworks, such as the Knowledge Spillover Theory of Entrepreneurship (KSTE), have adeptly explained the emergence of new ventures through the lens of knowledge dissemination (Acs et al., 2009; Audretsch et al., 2020; Audretsch & Keilbach, 2007). In recent years, they have offered crucial insights into green entrepreneurship (Cojoianu et al., 2020; Colombelli & Quatraro, 2019; Giudici et al., 2019). Startup success heavily depends on local knowledge factors, such as the innovative ecosystem in which they operate. Such a dependency may be especially pronounced for green startups, which are often characterised by more significant entrepreneurial risks and uncertainties due to the complexity and novelty of sustainable innovations (Cillo et al., 2019; Del Río et al., 2016). Consequently, the literature suggests that robust local ecosystems providing the necessary knowledge, infrastructure, and market conditions are especially needed by green startups (York et al., 2018).

Recent KSTE literature has screened the channels that turn knowledge spillovers into actual innovations, acknowledging that there are no direct or automatic mechanisms (Audretsch et al., 2021; Audretsch & Belitski, 2020). Only a few entrepreneurial efforts are highly innovative and lead to the formation of high-impact, high-growth companies that drive aggregate economic growth (Colombelli et al., 2016; Shane, 2009). Innovativeness is particularly relevant in the context of green startups because it enables them to address complex environmental challenges with new solutions, and positions them as key players in local economic development.

The innovation literature has comparatively neglected demand-side considerations (Di Stefano et al., 2012; Kalcheva et al., 2018), except for studies about demand-side policies like public procurement within and outside the green domain (Caravella & Crespi, 2021; Costantini et al., 2015). Yet, the uncertainty about the returns of investment in green products and technologies is a crucial hindrance to translating green entrepreneurship into successful innovative businesses, and plays a pivotal role in specific industries (Caiazza et al., 2020; Horbach et al., 2013; Rennings, 2000). Hence, understanding the role of demand factors along with local knowledge spillovers in green entrepreneurship is essential to fully characterise this phenomenon and inform policymakers aiming to foster sustainable economic development.

We aim to expand the scope of the KSTE by incorporating both supply and demand side factors, to better understand how technological and market opportunities translate into entrepreneurial emergence and regional innovation. While the KSTE primarily focuses on supply-side factors (the availability of knowledge and supportive, innovative ecosystems), we expand the framework to include demand-side factors that we deem particularly relevant for the emergence of green startups. We also explore the interaction between local demand for sustainable innovations and the size and composition of the local knowledge stock for green firm formation. In doing so, we contribute to the rising debate on the interplay between entrepreneurial ecosystems and knowledge spillovers, pointing

to the benefits of integrating demand as a contextual factor for entrepreneurial emergence (Morris et al., 2024; Qian, 2018).

An essential contribution of our paper lies in our original approach to identifying green startups. Existing methods are either based on patent or industrial classifications, focus on specific kinds of firms and technologies, or rely on manual inspections (Coll-Martínez et al., 2022; Colombelli & Quatraro, 2019; Corradini, 2019). We develop a flexible, scalable and time-efficient model that employs advanced machine learning algorithms to analyse the text of startups' websites and identify topics, which are then classified as "green" by referencing the targets of environment-related Sustainable Development Goals (SDGs). We apply our AI-based identification method to the Italian Registry of Innovative Startups, which contains data on the population of Italy's most innovative new companies, to capture new ventures with a high potential for growth and positive local impacts.

We employ this measure to empirically test our arguments at the province level, studying how local factors contribute to the formation of green innovative startups. We account for the role of the knowledge base through the total patent application stock and the proportion of such patent applications that are green. To approximate the demand for environmental sustainability (from now on referred to as "green demand"), we rely on a proxy that combines several indicators of environmentally sensitive behaviours using Principal Component Analysis (PCA). We are aware that this behaviour-based approach may not capture every aspect of green demand—e.g., market conditions like prices and availability of green products, policy incentives, access to services and infrastructure, or other contextual factors (Brouhle & Khanna, 2012; Joshi & Rahman, 2015). Yet, it offers a theoretically grounded and empirically relevant measure. Our justification for this proxy stems from established theories of green consumption values, environmental attitudes, and pro-environmental behaviours. Research underscores that green demand is rooted in environmental values, social norms, and behavioural patterns, all of which correlate strongly with a greater willingness to pay for sustainable products and with environmentally-conscious purchasing decisions (Farrow et al., 2017; Haws et al., 2014; Lee et al., 2023; Nguyen et al., 2016; Paul et al., 2016). By integrating these behavioural dimensions, we expect to capture the core drivers of green demand and align closely with this field's theoretical and empirical evidence.

Our results indicate that the local green demand is pivotal for the emergence of innovative green startups in Italian provinces. In line with the KSTE, we confirm that the local stock of knowledge is highly relevant for green startup formation and further identify positive interaction effects of local knowledge stocks and high levels of green demand in the area. These results suggest synergistic effects of supply and demand factors and indicate that green demand boosts local knowledge spillovers. Interestingly, we find that the spillovers that matter for green entrepreneurship arise from larger, rather than "greener", knowledge stocks. These results suggest that the overall territorial innovation capacity matters more than specific specialisation patterns for green entrepreneurship, which aligns with the green innovation literature that points to a critical role of local recombinant capabilities.

The article is organised as follows. Section 2 presents the theoretical background and hypotheses tested. Section 3 describes the data, variables, and empirical model. Section 4 discusses the main results and section 5 concludes.

2. Theoretical background and hypothesis development

To date, the KSTE is one of the key theoretical frameworks accounting for the creation of new innovative enterprises in a region. The KSTE predicates that large incumbent firms and organisations generate knowledge spillovers that constitute a unique business opportunity for potential entrepreneurs aiming to establish new innovative enterprises within a territory (Audretsch et al., 2015; Audretsch & Keilbach, 2007). However, available knowledge in a location is necessary but insufficient for innovation because knowledge transfer is not frictionless. Transforming knowledge stocks into economically valuable innovations requires enabling conditions at the local level, such as supporting institutions, knowledge intermediaries, regulatory frameworks and dedicated financial markets. The absence of these conditions creates a barrier or a cost – the Knowledge Filter (KF) – that hinders the transformation of broad knowledge into economic knowledge à la Arrow. To appropriate knowledge spillovers and transform them into commercially useful knowledge, potential entrepreneurs must (be set in the position to) penetrate the KF (Acs et al., 1994, 2004).

The KSTE is a story of knowledge opportunities: incumbents, mostly unwillingly, supply knowledge resources and thus create local spillovers and opportunities for innovative entrepreneurship. The abundance of knowledge spillovers directly increases the propensity to start a new venture in the same territory, as aspiring entrepreneurs attempt to exploit the opportunities that incumbent firms do not appropriate. New enterprises can develop more agile and flexible solutions to leverage the existing knowledge stock, possibly at a lower cost than large incumbents (Antonelli, 2013). Knowledge opportunities allow latent entrepreneurs and innovators to emerge, provided that they can recognise the chance, absorb the knowledge, and take risks to initialise and operationalise a new venture (Caiazza et al., 2020; Qian & Jung, 2017).

As such, the KSTE qualifies as a supply-side theory of innovation. It highlights the importance of the provision and accessibility of knowledge for entrepreneurship to emerge. It serves as a *liaison* between individual-level analyses on entrepreneurship determinants and studies about contextual-level factors. Specifically, it bridges the literature on individual motivations to take entrepreneurial risks and the research on the resources, institutions and culture that give the entrepreneurial effort a chance to start and perform (Audretsch et al., 2017; Autio et al., 2014). To further understand the role of knowledge spillovers in creating specific entrepreneurial opportunities, we test the KSTE on an interesting subset of nascent firms: innovative green startups.

Green innovative entrepreneurship can be challenging because it faces a double externality issue, taking place both at the invention and diffusion stages: inventors cannot entirely appropriate the returns from knowledge generation (the starting point of the KSTE), and the technology they produce positively affects a public good, the environment. Indeed, public support is particularly relevant for green knowledge creation and diffusion (Orsatti, 2024). Inventors can partially protect their potential returns from green innovations like any other innovation. However, the demand for their innovative green product or service may be weak because the innovation does not focus on generating private value but contributes to the maintenance of a public good. Hence, green innovations often result in knowledge creation and environmental benefits that are non-excludable and subject to market imperfections (Cohen & Winn, 2007). Therefore, prospective entrepreneurs face uncertainty about expected returns when starting a new "green" venture (Horbach et al., 2013; Rennings, 2000).

From a KSTE perspective, the relationship between knowledge availability/accessibility and innovation through firm creation should also hold true for green startups (Cojoianu et al., 2020; Colombelli & Quatraro, 2018; Giudici et al., 2019). The reliance on knowledge spillovers – a necessary but insufficient condition for innovative startup creation – could even be more relevant for green startups (Horbach et al., 2013). Indeed, green innovations show different, more demanding characteristics than non-green ones, as they are typically more complex and novel[1] (Barbieri et al., 2020). Thus, the spillovers from the existing stock of knowledge should be especially relevant for the creation of new green startups. Measuring the stock of knowledge with local patent applications, we test the following hypothesis:

H1: The larger the size of the stock of knowledge — proxied by patent applications — the higher the number of green innovative startups in a province

Recent literature advocates that a specific type of knowledge spillovers, namely those arising from green knowledge, matters especially for green entrepreneurship (Cojoianu et al., 2020; Colombelli & Quatraro, 2019; Giudici et al., 2019; Vedula et al., 2019). The argument is that, while general knowledge stocks offer a broad basis for new enterprise creation, the presence of green knowledge – R&D, innovative ecosystems, incubators and research centres focused on renewable technologies, circular economy, decarbonisation solutions, and so on – can boost green entrepreneurship in a targeted way. Green technologies and knowledge often display homophily[2] and path dependence and, therefore, might need a consolidated and specific set of skills, data, equipment and resources that can contribute to new green knowledge, green technologies and, ultimately, green ventures (Nomaler & Verspagen, 2019). The link between a subset of the knowledge stock and the equivalent type of entrepreneurial activity has been posited before, beyond the context of green startups: Bonaccorsi et al. (2013), for instance, identify an association between the specialisation of the knowledge created locally and the kind of innovative startups funded, and Colombelli et al., (2023) found evidence of this link for artificial intelligence startups.

Drawing from the diversity and innovation literature, we argue that the knowledge stock can be viewed as the sum of two components: a size and a composition component (Alesina et al., 2016; Antonelli et al., 2017, 2022). Both are expected to foster knowledge creation, whereas some ambiguity remains regarding the correlation between knowledge composition and performance (Antonelli et al., 2022). We focus on the green composition of the overall knowledge stock to assess the role of environmentally friendly knowledge. Whereas H1 explores the direct correlation with the size component, our second hypothesis tackles whether the stock's composition correlates with innovative green startup emergence.

[1] One could question whether green knowledge is intrinsically different from non-green knowledge or if such characteristics derive from green knowledge being the turbulent frontier of the knowledge space. Fusillo (2023) marks a step in this direction, but further research on the topic is warranted.

[2] High homophily in the context of knowledge creation means that green patents mostly cite green patents in prior art (Nomaler & Verspagen, 2019), but it does not necessarily correlate with measurement of knowledge recombination such as complexity, variety and novelty, mostly because green knowledge often is general and broad. Indeed, new knowledge can recombine creatively and unexpectedly knowledge from various domains within the same area, especially if the latter is general and broad.

H2: The larger the share of green knowledge — proxied by green patent applications — in the composition of the knowledge stock, the higher the number of green innovative startups in a province.

A crucial contribution of the present paper is to suggest that the KSTE, as a supply-side innovation theory, would benefit from incorporating demand-side economic forces. Theoretically and empirically, the interplay between supply and demand in innovation dynamics is a neglected research avenue (Kalcheva et al., 2018). The debate about whether demand or supply factors are the most influential in driving innovations peaked in the Seventies and was followed by a substantial body of research on the supply side or technology-push perspective, claiming that the provision of knowledge through R&D investments and science is a key engine of the gales of innovation and growth. On the contrary, the research on demand for innovations focused more on pull effects, directing "the trajectory towards the right economic venues" (Di Stefano et al., 2012, pp. 1291). Recent works have started to look at the interplay between demand and supply: for instance, Kalcheva et al., (2018) show that, in the medical industry, shocks to the demand for new products significantly impact the innovation process, particularly when they take place in territories with a high supply of knowledge through a multiplicity of channels.

The interplay between supply and demand side forces is especially topical in the context of eco-innovations and green entrepreneurship. The literature is currently exploring a wide range of push and pull factors, but no universal consensus has been reached, and plenty of gaps remain (Abdesselam et al., 2024; Del Río et al., 2016; Rehfeld et al., 2007). One of the most significant hurdles to the successful diffusion of green products and services is achieving a competitive price relative to non-green alternatives (Rehfeld et al., 2007). Hence, demand-pull forces should play a crucial role in determining the decision to invest and enter the market, even though they might have a milder impact on investment intensity (Kesidou & Demirel, 2012).

Hence, we want to test the theoretical argument that the demand side is particularly relevant in the emergence of innovative new firms in the green domain. Since green innovations tackle a wide range of environmental externalities – from pollution to waste, greenhouse gas emissions to biodiversity loss, resource depletion to ecosystem degradation – they partially suffer from the same market inefficiencies of public goods. Consequently, they struggle to find a clear local demand. The first step for entrepreneurial emergence is the recognition of a positive pay-off leading to a high expected value of the innovation investment (Caiazza et al., 2020). Hence, in the presence of a strong demand signal, the willingness to start a risky green enterprise is expected to increase as the uncertainty over future pay-offs lowers.

Moreover, corporate stakeholder theory asserts that consumer pressure is a crucial incentive for green innovation investments because it signals consumers' willingness to pay and enacts organisational learning, particularly for product innovation (Wong, 2013; Zhang & Zhu, 2019). Indeed, product innovation, being more explorative and uncertain than process innovation, requires considering consumers' preferences and coordinating with them. The clearer and more intense the consumers' demand, the stronger the opportunities to profit from innovative capabilities, provided enough and immediate firm responsiveness (Roome & Wijen, 2006). At the same time, green innovations can address the unmet demand for sustainability of local stakeholders and feed the creation and

exploitation of new market niches (Schaltegger & Wagner, 2011). Overall, we expect a positive link between local demand and innovative green entrepreneurship. As discussed in detail in the data section, we operationalize local green demand with an index combining different local green behaviours to proxy for sustainability-oriented demand in a territory, leading us to our third hypothesis.

H3: The higher the green demand — proxied by local green behaviours — the higher the number of green innovative startups in a province.

Building on the previous arguments, we posit that demand forces affect and shape the KF. The above reasoning regarding knowledge spillovers and demand should hold for every kind of innovative entrepreneurship. Still, we propose that the interplay between demand and knowledge spillover availability in a territory matters particularly for green startup emergence. Green innovation often arises from recombining multiple local knowledge bases, not necessarily belonging to green-specific domains (Fusillo, 2023; Orsatti et al., 2024; Quatraro & Scandura, 2019), which makes green knowledge particularly susceptible to knowledge spillovers. Moreover, green innovations' intrinsic market and knowledge characteristics constitute a disincentive to embark on a risky endeavour, strengthening the KF due to high uncertainty and low expected short-term returns (York & Venkataraman, 2010). However, if demand for environmental sustainability manifests, it constitutes a counterbalancing force and softens the KF because it increases short-term expected returns on the innovation investment. In other words, the green arena is one of the best contexts to provide new evidence of the supply-demand nexus in entrepreneurial research.

The literature has extensively studied the impact of non-market forces, such as pro-environmental institutions, on local absorptive capacity in the form of opportunity recognition (Vedula et al., 2019). Some studies have shown that environmental sensitivity informs policymakers' actions towards supporting regulations (Cojoianu et al., 2020; Coll-Martínez et al., 2022; Giudici et al., 2019), a crucial antecedent of green innovation (Santoalha & Boschma, 2021). The entrepreneurial ecosystems literature stresses the importance of contextual factors (such as institutions, culture, infrastructure, demand, networks, finance, talent, and support services) in determining startup emergence (Spigel, 2017; Stam, 2015). However, this literature does not directly address the moderating role of contextual factors on the appropriation and commercialisation of knowledge spillovers. Importantly, even though previous studies have not enlisted local demand among the key contextual factors that should matter for the KSTE (Qian, 2018), we argue that the current form of the KSTE as a supply-side theory of entrepreneurial emergence would greatly benefit from an approach that also accounts for demand-side forces.

Overall, a natural implication of the KSTE is that the size of the stock of knowledge positively interacts with green demand. If the knowledge stock captures the availability of marketable knowledge opportunities, and green demand reduces the risk of converting such opportunities into entrepreneurial ventures, a combination of the two is expected to increase green entrepreneurship.

H4a: Green demand — proxied by local green behaviours — positively moderates the relationship between the size of the stock of knowledge and green startups.

A related question concerns whether the specific composition of the knowledge base, in this case, the "greenness" of such knowledge stock, will play a particular role in interaction with local demand forces. If innovative green entrepreneurship is particularly reliant on green knowledge, a context marked by a "greener" stock of knowledge will produce "greener" spillovers and give rise to opportunities with a more marked green content, making demand more effective in weakening the KF.

H4b: Green demand — proxied by local green behaviours — positively moderates the relationship between the share of green knowledge and green startups.

3. Empirical framework

3.1. Data

3.1.1 Innovative startups

For our analysis, we rely on the population of so-called "innovative startups" in Italy. In 2012, the Italian government launched the Italian Startup Act, granting various forms of support to young, innovative, and highly skilled new companies. To qualify to register as an innovative startup at the Italian Chamber of Commerce, small young startups must provide evidence for at least one of these pre-requisites: (i) at least 15% of production costs or value invested in R&D expenditure; (ii) at least 1/3 of the employees hold a PhD or 2/3 of the employees hold a master's degree; or (iii) at least one patent or equivalent proprietary knowledge. As of May 2023, 26,891 Italian startups were registered at the chamber of commerce. These startups represent a subset of companies with high innovation capacity and considerable growth potential, and therefore, they constitute a suitable sample to study applications of the KSTE in terms of novel green value creation. From this initial sample, we used AIDA, an Amadeus-Bureau Van Dijk database, to access relevant information about the startups, such as firm characteristics and location. Innovative startups in our sample concentrate in Italy's most dynamic economic centres, such as in Lombardy and Lazio's regions, particularly in large provinces like Milan and Rome. Figure 1 maps their distribution in Italian territory.

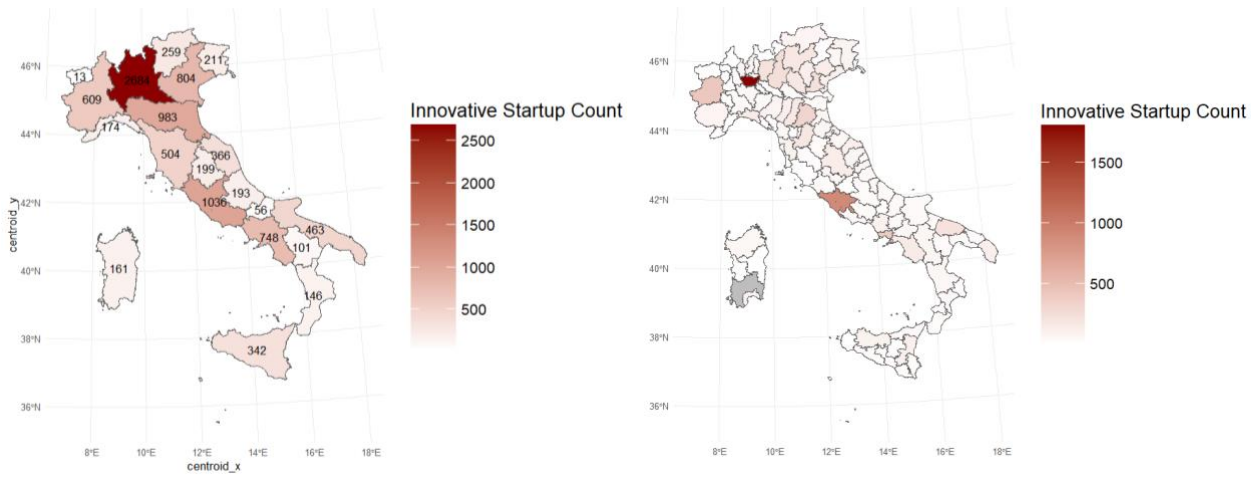


Figure 1 Count of innovative startups at the regional and province level as of May 2023. Source: authors' own elaboration on data from the Italian Chamber of Commerce.

As a first step, we must identify green startups in the sample. However, this task is not straightforward: there is no consensus on the definition of a "green startup" in the literature (see for example the discussions in Colombelli et al., 2024; Gast et al., 2017; Purvis et al., 2019), nor a single empirical approach to tag them (Colombelli & Quatraro, 2019, Tiba et al., 2021, Jha & Pande, 2024, Gidron et al., 2023). We develop a new approach that leverages the recent developments of Natural Language Processing, using BERTopic (Grootendorst, 2022) to extract topics from the startups' website, and in parallel, we identify topics related to SDG environmental targets as green (see Figure 2 for a summary of the procedure, and Online Appendix A for a detailed overview of the whole algorithm). Ultimately, we tag 1'529 Italian innovative startups as "green".

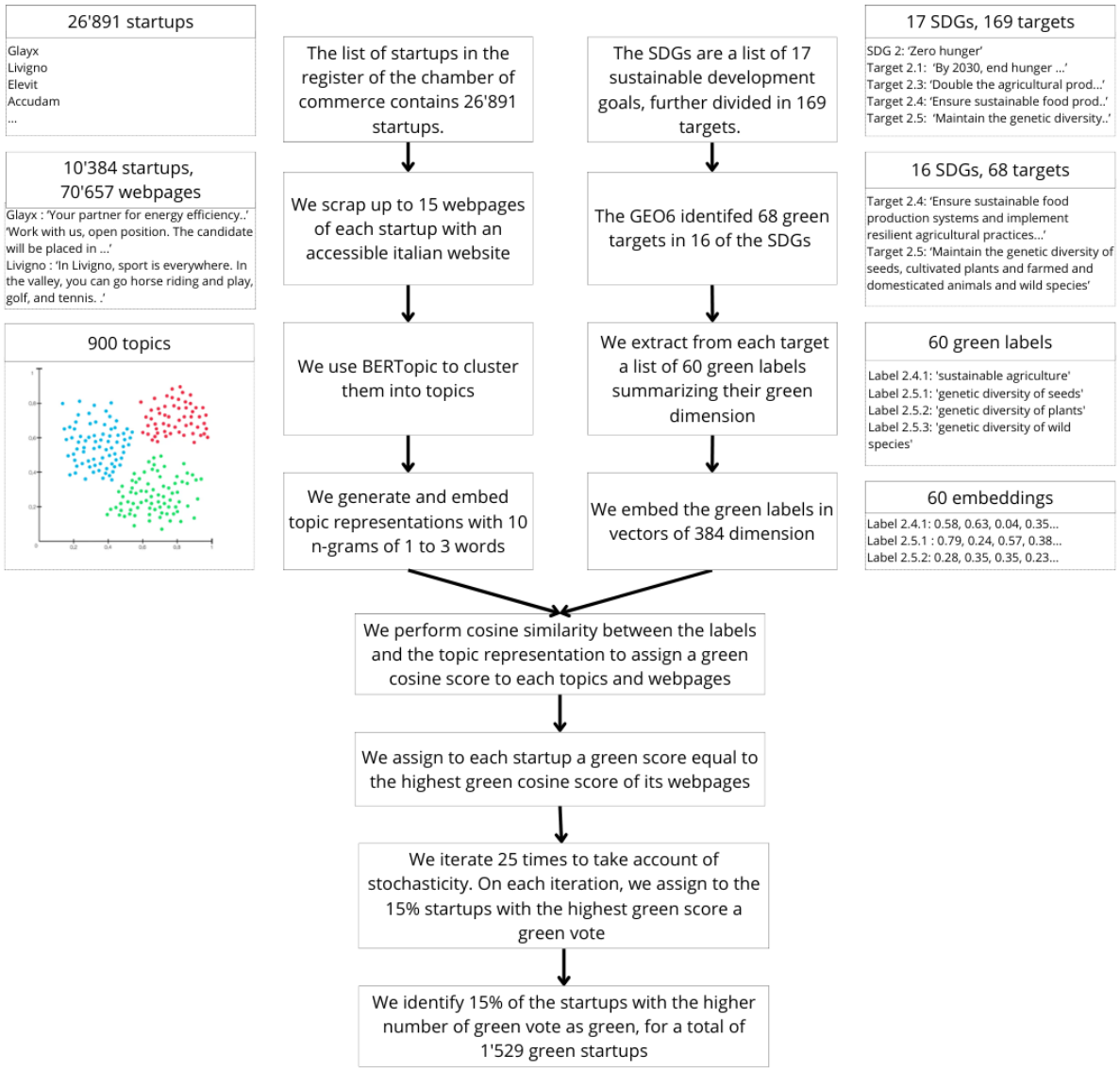


Figure 2 – Summary of the green startup identification process through BERTopic, comparing it with targets from green sustainable development goals (SDGs). Sample of all Italian innovative startups.

Figure 3 shows the share of our green innovative startups per region and province. The distribution shows a high concentration of green entrepreneurial activity in specific provinces. Still, it should be noted that these are also locations with few total startups (Oristano in Sardinia has nine innovative startups, among which four are green, and Ragusa in Sicily has 20, among which nine are green). Milan and Rome, while having the highest number of total innovative startups, as shown previously in Figure 1, have a relatively low rate of green startups, with 13% and 12%, respectively.

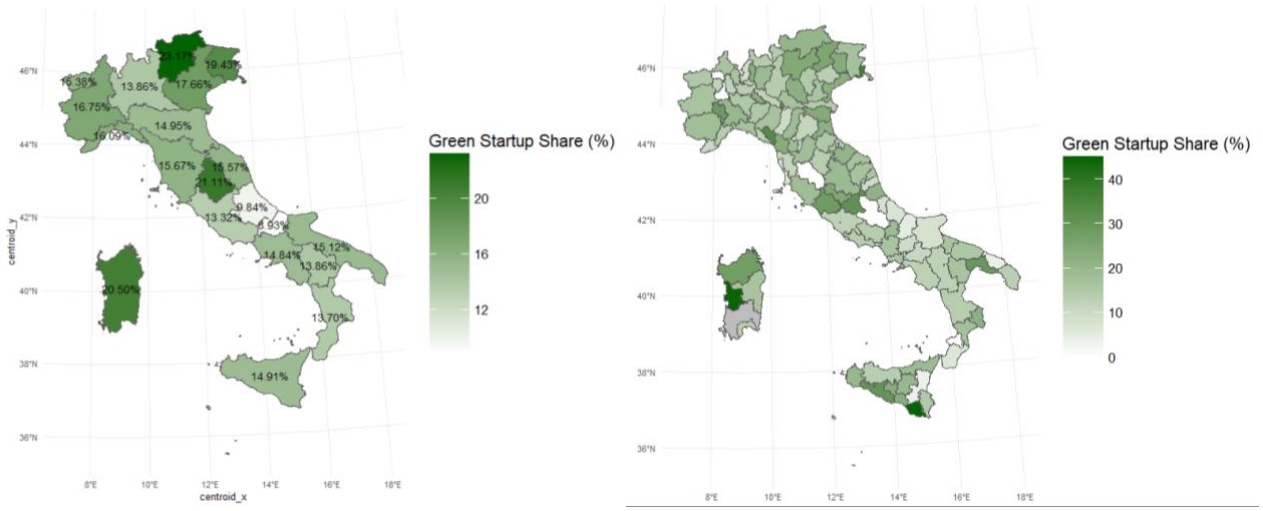


Figure 3 - Share of green startups identified by BERTopic with green SDG targets in Italian regions and provinces

3.1.2 Operationalising the KSTE: knowledge stock and its "greenness".

The presence of a vibrant knowledge ecosystem qualified by the availability of useful knowledge has long been operationalised with the stock of patent applications at the territorial level whenever the focus of the analysis was explicitly on innovation outcomes (Acs et al., 2009; Colombelli & Quatraro, 2018, 2019; Mokyr, 2011). As discussed in the previous section, we depart from prior literature on green entrepreneurship (Cojoianu et al., 2020; Colombelli & Quatraro, 2019; Giudici et al., 2019; Vedula et al., 2019) and measure two characteristics of such knowledge stock: its size and composition (Alesina et al., 2016; Antonelli et al., 2017, 2022).

To measure the size component of the knowledge stock at the highest possible level of granularity (NUTS3), we measure it from the output side based on patent applications (Acs et al., 2009; Hall et al., 1986). We are aware of the limitations of patents as a measure of innovation – not all patents represent innovation, many innovations are not patented, the propensity to patent differs across industries, and patents downplay innovation in service industries. Yet, patents remain the most widespread used proxy for measuring innovation due to their availability at different levels of aggregation and over time.

To measure the composition of the total knowledge stock, we assess the extent to which the knowledge stock is green. We identify green patents based on their Cooperative Patent Classification (CPC) code as all patents falling in the Y02 class and, for each year and province, compute the share of the patent stock that is attributable to green patents as

$$GPSH_{i,t} = \frac{GREEN_KSTOCK_{i,t}}{KSTOCK_{i,t}}$$

Conditional on a given patent stock, this simple share captures the extent to which local knowledge is more or less intensive in green knowledge and, thus, is a reasonable proxy of the green composition of local knowledge. In a robustness check, we study the robustness of our results to the inclusion of $GREEN_KSTOCK$ directly in the estimation, in line with existing literature (Audretsch et al., 2020; Cojoianu et al., 2020; Colombelli & Quatraro, 2019; Giudici et al., 2019; Vedula et al., 2019). Figure 4 shows the patent stock in Italian provinces for 2022, the last year of the analysis.

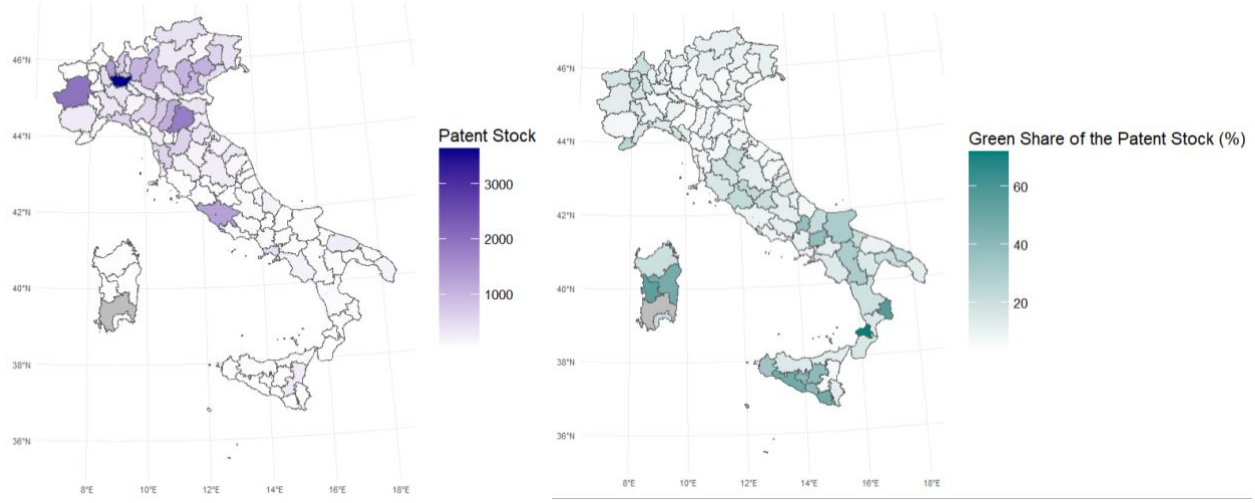


Figure 4 – Patent stocks and green share of the patent stocks in Italian provinces as of 2022

3.1.3 Green demand index from local green behaviours

As argued in Section 2, we want to test whether the demand side plays a role in the emergence of innovative new firms in the green domain. Operationalising the demand for environmental sustainability is challenging due to the complex interplay of environmental sensitivity, actual behaviours oriented to protect the environment, and disposable income. Previous studies have confirmed the role of self-assessed environmental sensitivity in green startup creation (Giudici et al., 2019). However, subjectively stated environmental sensitivity does not necessarily correlate with environmentally sustainable behaviours. The expected success of green startups critically relies on environmentally sustainable behaviours and not simply self-declared green sensitivity: these startups can only expect to thrive if their target consumers enact pro-environmental behaviours and choose their products and services against alternative, more polluting ones. Drawing on these considerations, our operationalisation focuses on proxies for environmentally sustainable behaviours at the highest possible granularity level, which is once again the NUTS3 level.

The Italian National Institute of Statistics (ISTAT) data on the quality of urban environment appear ideal to this end.[3] A broad range of data relating to the quality of urban mobility, waste collection, and pollution are collected yearly for province capitals. The set of variables has evolved over time, but information about the core variables is available yearly for about one decade. In choosing the variables that we use to construct our measure for green demand, we must balance the need to ensure

[3] See, e.g., https://www.istat.it/it/archivio/291918

a sufficiently long time coverage with the aim to represent the variety of green behaviours with a reasonably broad set of variables. The result of this process is the following selection of variables, all available yearly from 2012 to 2022: availability of bike-sharing services; availability of car-sharing services; bike lane density; demand for local public transportation services; days exceeding the acceptable limit of PM10 concentration in urban air; share of recycled/sorted waste on total waste; motorisation rate (i.e., motor-vehicles per inhabitant).

To obtain a proxy for green demand, we combine these variables in a single index through a principal component analysis (PCA, Afifi et al., 2019). PCA identifies linear combinations of the variables that explain the largest component of the covariance. Applying this methodology to our variables, we obtain seven principal components, the first of which explains 37.4% of the overall variance. The relative factor loadings are reported in the Online Appendix B (Table B1).

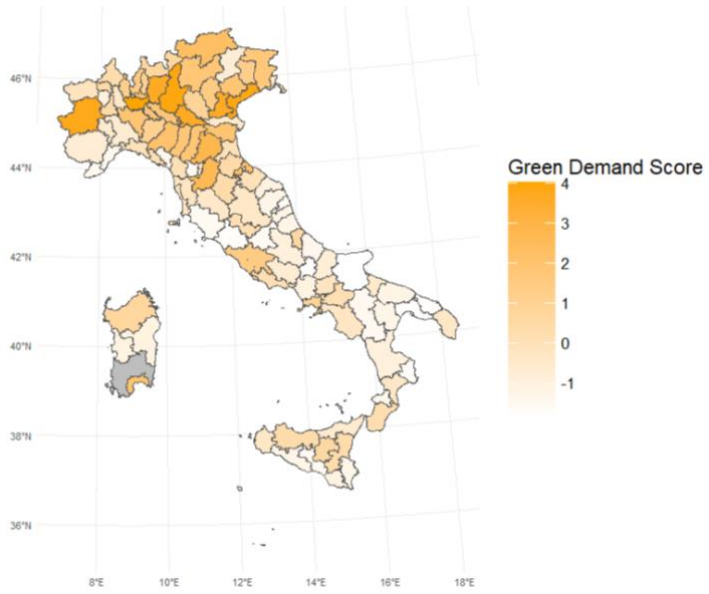


Figure 5 – Green demand score in Italian provinces as of 2021

In addition to the key variables of interest and consistent with previous literature, we also include a set of controls in the empirical analysis that capture local socio-economic conditions: firm density, value added, the share of manufacturing, the share of graduates, and the unemployment rate. Our variables' description, summary statistics and correlation matrix are reported in the Online Appendix B (Tables B2, B3, and B4, respectively).

3.2 Empirical model

Our dependent variable's discrete and non-negative nature motivates the adoption of count data models (Cameron & Miller, 2015; Hausman et al., 1984) to estimate our relationship of interest. Due to the remarkable overdispersion in our dependent variable, we expect the negative binomial estimator to be more efficient than the Poisson estimator (Greene, 2003). Our baseline model is:

$$GREEN_STARTUPS_{i,t}=exp(\alpha + \beta_1 KSTOCK_{i,t-1} + \beta_2 GPSH_{i,t-1} + \beta_3 GREENDEMAND_{i,t-1} + Z\gamma + \rho_r\delta + \psi_t\vartheta + \epsilon_{i,t})$$

where Z represents a vector of control variables, ρ_r is a vector of NUTS2-level regional dummies, ψ_t a vector of time dummies, $\epsilon_{i,t}$ is a random error component, and $\alpha, \beta_1, \beta_2, \beta_3, \gamma, \delta, \vartheta$ are parameters or parameter vectors to be estimated. We lag all our regressors by one year to account for the time necessary for knowledge creation to translate into knowledge diffusion and appropriation. However, we refrain from any causal interpretation (Bellemare et al., 2017).

The sign and significance of the marginal effects of *KSTOCK* and *GPSH* provide evidence addressing Hypothesis H1 and H2, respectively. The sign and significance of the marginal effects of *GREENDEMAND* test hypothesis H3.

Hypotheses H4a and H4b concern interaction effects. In the presence of non-zero interaction effects, the model equation becomes:

$$\text{GREEN_STARTUPS}_{i,t}=\exp(\alpha + \beta_1 KSTOCK_{i,t-1} + \beta_2 GPSH_{i,t-1} + \beta_3 GREENDEMAND_{i,t-1} + \beta_4 KSTOCK_{i,t-1} \times GREENDEMAND_{i,t-1} + \beta_5 GPSH_{i,t-1} \times GREENDEMAND_{i,t-1} + Z\gamma + \rho_r\delta + \psi_t\vartheta + \epsilon_{i,t})$$

The econometric literature on non-linear models specifies that the coefficient of the interaction term is not equal to the marginal effect of the interaction (Ai & Norton, 2003; Mize, 2019). Although the problem is less severe for exponential models like the Negative Binomial and Poisson, we follow Mize (2019) in analysing the presence of moderating effects with a graphical inspection of how marginal effects change for different levels of another variable of interest. Finally, in a set of robustness checks, we show the robustness of our results to alternative count model estimators (Poisson and Zero-Inflated Negative Binomial).

4. Results

In Table 1, we test our hypotheses about green startup formation. In line with the KSTE and hypothesis H1, the results consistently indicate that a higher stock of knowledge is significantly associated with higher firm formation (column 1)[4]. However, when we exploit the availability of data on both the size (total stock of patent applications, *KSTOCK*) and the composition (share of green stock over total knowledge stock, *GPSH*) of the knowledge stock (from column 2 onward), we obtain rather unexpected insights. Our results do not indicate that the green component of the knowledge stock has a specific effect on green entrepreneurship, contradicting hypothesis H2. In other words, we observe a significant correlation between green startup emergence and the *size* of the knowledge stock, but we do not witness a statistically meaningful relationship with its *composition*. Altogether, results about H1 and H2 indicate that green startup emergence requires a vibrant local knowledge ecosystem rather than a specialised knowledge trajectory.[5]

Turning to hypothesis H3, the evidence in column 4 of Table 1 confirms the expectation of a positive and statistically significant association between the green demand index *GREENDEMAND* and green

[4] We test and confirm that stylized facts about knowledge spillovers apply to total startups, too (results available upon request).

[5] We check that the mean variance inflation factors corresponding to the linear version of our specifications are all below the conventional value of 10, reassuring that multicollinearity should not be a major issue for our estimates.

entrepreneurship. In line with our theoretical reasoning, more pro-environmental behaviours in a territory go hand in hand with greener entrepreneurship. Column 5 addresses hypotheses 4a and 4b by introducing the interaction between green demand and knowledge stocks. Coherently with the above results, the size component of the knowledge stock turns out positive and significant, while the green composition component is not statistically significant. For the sake of completeness, in column 6 of Table 1, we also consider the results of a model that excludes knowledge stocks. The estimates confirm the significance of green demand for green entrepreneurship.

Table 1. Green firm formation

	(1)	(2)	(3)	(4)	(5)	(6)
KSTOCK	0.744***	0.801***	0.584***	0.487***	0.450***	
	(0.115)	(0.116)	(0.106)	(0.091)	(0.078)	
GPSH		2.246	0.934	0.743	-2.113	
		(1.426)	(1.211)	(1.174)	(1.644)	
PC_VADDED			0.977	0.618	0.238	4.433***
			(1.368)	(1.137)	(1.140)	(1.077)
GRADSH			0.132	0.105	0.076	0.191
			(0.139)	(0.134)	(0.144)	(0.123)
MANUF_SH			-3.638	-3.612	-3.938*	-3.162
			(3.500)	(2.341)	(2.213)	(2.089)
FIRM_DENS			0.006***	0.006***	0.005**	0.008***
			(0.002)	(0.001)	(0.002)	(0.001)
UNEMPL			-0.024	-0.028*	-0.020	-0.023
			(0.016)	(0.016)	(0.014)	(0.019)
GREENDEMAND				0.257***	-0.608	0.492***
				(0.080)	(0.380)	(0.096)
KSTOCK × GREENDEMAND					0.145**	
					(0.061)	
GPSH × GREENDEMAND					-0.752	
					(0.947)	
_cons	-5.742***	-6.419***	-15.467	-10.898	-6.281	-50.008***
	(0.901)	(1.008)	(14.647)	(12.122)	(12.269)	(11.907)
/						
lnalpha	-1.156***	-1.214***	-1.756***	-1.907***	-2.320***	-1.397***
	(0.345)	(0.313)	(0.400)	(0.348)	(0.312)	(0.346)
N	952	952	952	952	952	952
Region FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

Negative binomial regression coefficients. Dependent variable: number of green startups. Standard errors clustered at the regional level are in parentheses. All regressors lagged one year. *p<0.10, **p<0.05, ***p<0.01.

Table 2 reports the marginal effects corresponding to the key specifications in columns 4 and 5 of Table 1 to more immediately convey the magnitude of the estimated effects on the predicted number of new startups. In the case of a negative binomial model, coefficients capture the effect of a unit

change in the explanatory variable on the log of the expected counts of the response variable, holding other factors constant. To make the interpretation more straightforward, we thus include the marginal effects – which, in our context, can be interpreted in the standard sense as the effects of a unit increase in the regressor on the predicted number of startups. With regards to the interaction effects, we study the moderating role of green demand on knowledge stock size and composition graphically (Ai & Norton, 2003; Mize, 2019). Figure 6 and Figure 7 show how the marginal effects of the size of the total knowledge stock and its green composition change for different levels of green demand.

Table 2. Green firm formation (Marginal effects)

	(1)	(2)
KSTOCK	0.663***	0.781***
	(0.129)	(0.147)
GPSH	1.011	-3.745
	(1.598)	(3.114)
GREENDEMAND	0.349***	0.435***
	(0.110)	(0.146)
PC_VADDED	0.841	0.327
	(1.547)	(1.568)
GRADSH	0.143	0.105
	(0.182)	(0.197)
MANUF_SH	-4.911	-5.410*
	(3.206)	(3.044)
FIRM_DENS	0.009***	0.007**
	(0.002)	(0.003)
UNEMPL	-0.037*	-0.028
	(0.021)	(0.020)
N	952	952
Region FE	YES	YES
Year FE	YES	YES

Negative binomial regression. Marginal effects (predicted number of startups) corresponding to the specifications in columns 4 and 5 in Table 1. Delta method standard errors are in parentheses. All regressors lagged one year. *p<0.10, **p<0.05, ***p<0.01.

Overall, our results imply rather sizeable effects of our variables of interest. A 1% increase in the knowledge stock (more precisely, a unit increase in the inverse-hyperbolic-sine-transformed stock of patent applications *KSTOCK*) implies an increase in the predicted number of green startups by 0.663, holding other factors constant (Column 1 of Table 2). A 1% increase in the knowledge stock is non-trivial, given the uneven distribution in the untransformed patent stocks across provinces. For illustration, considering that the median number of green startups per province in our sample is 1, this implies that increasing the knowledge stock from the level of the province of Palermo (whose knowledge stock corresponds to the 25th percentile of the distribution in 2020) to the level of the province of Lodi (corresponding to the 55th percentile) would double the predicted number of green

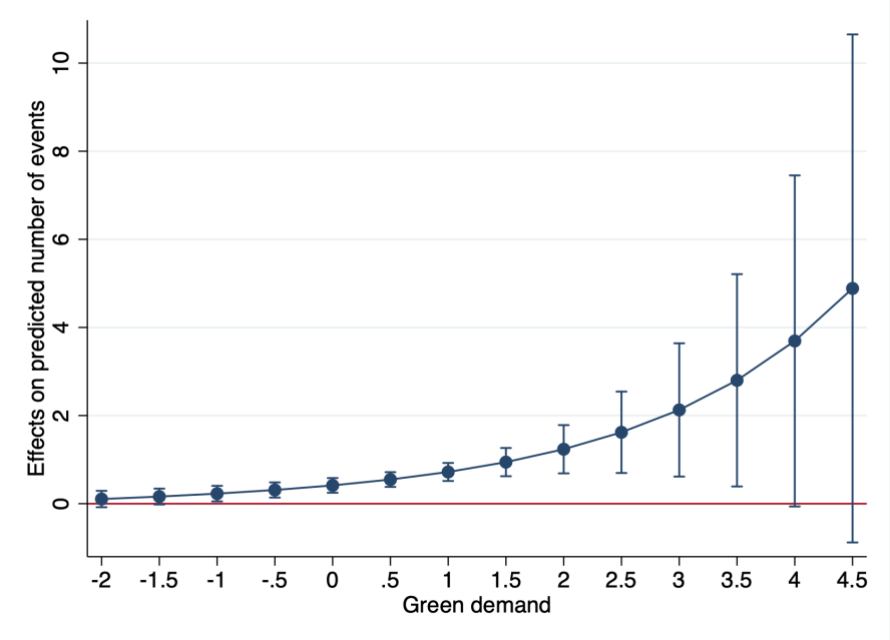
startups. However, when interpreting the results, we should note that in our empirical analysis, we cannot make any claim of causal interpretation.

For further context, the median number of patent applications per year is 19, so increasing the number of patent applications filed by 1% implies one or two additional patents but, over the years, about 20% of the provinces in our sample have filed zero patent applications. Therefore, this estimate refers to an average effect, but we expect these relationships' economic size to be highly heterogeneous across the Italian territory.

In turn, increasing the green demand index by 1% (a unit increase in the inverse-hyperbolic-sine-transformed green demand index *GREENDEMAND*, corresponding to about one standard deviation in the index) leads to about 0.349 additional green startups, everything else equal (Column 1 of Table 2).

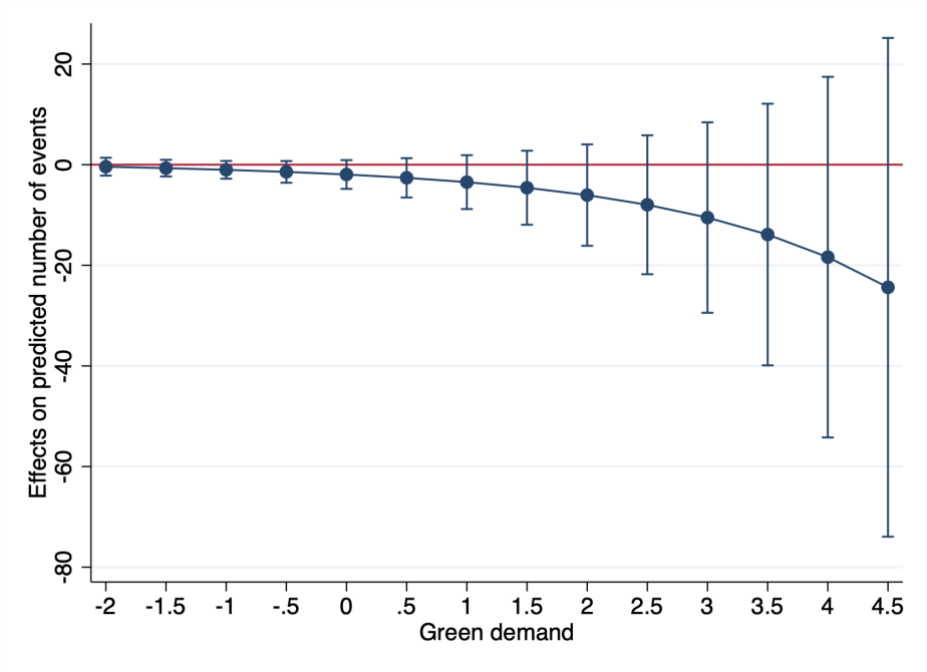
In line with the considerations about hypotheses H1 and H2, the graphical analysis reveals a positive and statistically significant moderation effect for the knowledge stock's size but not for composition. As the green demand index increases, the effect of local knowledge stock gets magnified (Figure 6). The effect is most precisely estimated for small-to-moderate levels of green demand due to numerosity in this range of values (95% of the observations have values of the green demand index below 3.5), yet it is unambiguously increasing. This suggests that the local demand for environmental sustainability activates the potential for local knowledge stocks to promote green entrepreneurship. Instead, Figure 7 shows that higher shares of green knowledge do not significantly interact with our proxy for the local demand for environmental sustainability. The estimated impact of the share of green knowledge appears to be declining with green demand, pointing to the possibility of substitution between the two. Overall, we interpret these results as evidence that what matters for green entrepreneurship is the presence of knowledge rather than *green* knowledge and that green demand acts as a trigger to activate local knowledge for green entrepreneurship.

Figure 6. Average marginal effects of knowledge stocks at different levels of green demand



Estimated marginal effects of knowledge stocks on **green** firm formation at different levels of green demand. 95% confidence intervals.

Figure 7. Average marginal effects of the share of green knowledge at different levels of green demand



Estimated marginal effects of the share of green knowledge on **green** firm formation at different levels of green demand. 95% confidence intervals.

4.1 Robustness

We apply four approaches to test the robustness of our results. First, we show that our findings match the existing literature when we restrict the analysis to green knowledge stocks. Second, we consider an alternative operationalisation of green startups. Third, we consider alternative estimators. Fourth, we introduce a measurement capturing the tacit component of knowledge better and refine our estimates' precision.

As a first robustness check, we compare an estimation considering only green knowledge stocks, versus one with only non-green knowledge stocks – and the usual baseline variables for green demand, interaction with knowledge stocks, and controls. We find that the estimated impact of green knowledge stocks of patent applications on green entrepreneurship, while positive and significant and significantly mediated by green demand, is empirically indistinguishable from that of non-green knowledge (Table B5 and Figure B1 in the Online Appendix B). This result confirms that the size of knowledge matters rather than its composition.

In a second robustness check, we apply our specification to a different dependent variable: energy startups. The latter is a more established, although more restrictive, measure of green entrepreneurship (e.g., Colombelli & Quatraro, 2019). We see that the estimated marginal effects of the knowledge stock and green demand on energy entrepreneurship are smaller but still significant with this measure (Table B6 in the Online Appendix B). Again, we do not find significant effects of the green composition of the knowledge stock.

Furthermore, we check the robustness of our results by employing different estimators, the Poisson and Zero-Inflated negative binomial regressions. The Poisson estimates largely confirm the above

results (Table B7 in the Online Appendix B). Again, the local knowledge stocks and green demand index correlate significantly with entrepreneurship, while the effects of the share of green stocks are not robust on their own or in interaction.

A remaining concern may be that our measure of knowledge stock captures mostly codified knowledge and neglects the role of tacit knowledge in green firm formation (Polanyi, 1966). To address this challenge, we note that STEM graduates possess technical expertise, analytical skills, and problem-solving abilities that are critical for developing innovative solutions to environmental challenges (Audretsch et al., 2002). This knowledge base should support green startup emergence, which often requires advanced scientific and technological insights to create sustainable products or processes, such as renewable energy technologies, green manufacturing, or eco-friendly materials. STEM graduates frequently develop this knowledge through hands-on experience in labs, research projects, or internships (Amoroso et al., 2018).

Hence, we expect more STEM graduates in a region to proxy for the presence of a concentrated pool of individuals who can address local environmental challenges. To gain insights into this aspect, we collect province-level data about the graduates in STEM fields from the European Commission ETER database on higher education institutions[6]. This variable, *STEMGRAD*, can be computed for a shorter period than our main database, and is highly collinear with our graduate share measure. Hence, we only add it as a control in a further robustness check, eliminating the graduate share from the control variables. The results are reported in Table B8 in the Online Appendix B. The results generally confirm our main findings about the complementarity of the knowledge stocks with green demand, even controlling for this further measure of tacit knowledge.

5. Discussion and conclusions

Based on theoretical and empirical arguments, in this paper we have suggested that the Knowledge Spillover Theory of Entrepreneurship may be fruitfully expanded by integrating the role of demand-side factors, especially in relation to the analysis of green entrepreneurship and its innovative expressions. Indeed, our findings are consistent with the established result that knowledge spillovers are more likely to arise in areas rich of knowledge, but, in addition, they confirm a crucial role of demand-side factors. Proxying green demand with sustainability-oriented behaviours, we not only find a role of green demand per se, but also a specific interplay of green demand with local knowledge. The results suggest that green demand makes it easier for firms to effectively leverage knowledge spillovers to start new businesses. Green demand acts as a factor that softens the Knowledge Filter because it increases short-term expected returns on the innovation investment, ultimately allowing knowledge spillovers to be converted into new innovative businesses more swiftly. Moreover, regions with more widespread green behaviours that lead to higher green demand are more likely to have pro-environmental institutions and greater local absorptive capacity in the form of opportunity recognition (Cojoianu et al., 2020; Coll-Martínez et al., 2022; Giudici et al., 2019; Vedula et al., 2019). Finally, we find some indications that both tacit and codified knowledge play a role in sustaining green startup emergence, although we cannot fully disentangle the tacit and codified components and invite future research to focus on this.

[6] For more information, see https://eter-project.com/.

Somewhat unexpectedly, our results suggest that the specific environmental content of the knowledge spillovers matters relatively little. Indeed, when explicitly comparing the size and composition of the knowledge stocks, we find that only the former matters for green entrepreneurship. Accordingly, only the total stock of knowledge significantly interacts with green entrepreneurship. These results indicate that innovative green entrepreneurship relies on total rather than green knowledge, which can be interpreted in the light of the recombinant knowledge theory.

Similarly to green technologies, green businesses may be viewed as standing at the technological frontier and representing the commercialisation of complex and radically innovative business ideas (Barbieri et al., 2023; De Marchi, 2012; Fusillo, 2023; Fusillo et al., 2022). Rather than the outcome of a specifically green pattern of spillovers, green innovation is often the result of the hybridisation of diverse and heterogeneous technologies and knowledge sources and the creative recombination of green and non-green technologies (Colombelli & Quatraro, 2019; Dechezlepretre et al., 2017; Messeni Petruzzelli et al., 2011; Zeppini & Van Den Bergh, 2011). In particular, non-green complementary technologies play a crucial role in green innovation (Barbieri et al., 2023; Fusillo, 2023; Orsatti et al., 2020). These arguments clarify why green demand interacts significantly with the total stock of knowledge but not with its composition. At the same time, the availability of green demand emerges as a leading factor enabling the conversion of diversified knowledge opportunities into innovative green entrepreneurship.

We invite future research to develop this intriguing finding further. Further studies may investigate whether green demand interacts in specific ways with the relatedness or unrelatedness of knowledge (Frenken et al., 2007; Saviotti, 1988) and with the breadth and depth of the local knowledge stock (D'Ambrosio et al., 2017; Laursen & Salter, 2006) to foster green entrepreneurship. Also, future research may investigate the role of green demand in conjunction with market concentration, particularly the possible opposition of large incumbent green firms (Akcigit & Van Reenen, 2023).

While endeavouring to enrich the KSTE with novel insights, our study still suffers from some limitations. First, as discussed, our empirical measure of demand is based on pro-environmental behaviours. Extensions of this work could include more direct measurements of the demand for green products or services, such as consumer surveys, choice experiments, field experiments or lab experiments in the field, willingness-to-pay elicitation methods, and so on.

Second, our results rely on the novel AI-powered web-based methodology that we have developed to identify green startups. On a positive note, this makes our identification of green startups substantially more granular and suitable for embracing the green business phenomenon at large. By construction, we encompass a broader range of firms than previous literature, and our results pertain to a wide spectrum of firms developing novel products or process and service solutions in a B-to-B or B-to-C environment. On the other hand, the same arguments imply that our application does not necessarily compare with previous operationalisations, such as in the case of studies of energy firms. Still, the robustness of our results to the subset of energy startups and their alignment with previous literature confirm that the drivers we identify for green startups at large are broadly relevant, hence reassuring our results' external validity.

Moreover, using startups' websites as the basis for defining a green business is not free from limitations. We expect that most sustainability-oriented startups will highlight these priorities on their websites. However, not all startups have the resources or expertise to create comprehensive websites, and some may not have the necessity to communicate with their stakeholders through a website (for

instance, B-to-B companies), resulting in their being underrepresented in our analysis. Furthermore, as information on the websites is self-reported by companies, there is the risk that some companies, due to the increasing interest in sustainability in society, will overstate their green initiatives with exaggerated claims akin to greenwashing (Montgomery et al., 2023). Our approach could, therefore, capture some false positives and tag them as green startups. However, we observe that green startups without a website are equally distributed in Italian territory. Since our analysis is at the province level rather than for the individual firm, we expect that the prevalence of greenwashing should not vary dramatically between locations (Tiba et al., 2021).

Another limitation is that our empirical analysis cannot distinguish green companies based on innovations at the level of products, services, processes or business models. Future development of large language models could explore ways to identify such information from companies' websites and categorise startups accordingly. We suppose that the relevance of knowledge spillovers and local demand is not equal across all these typologies of green businesses. Thus, it would be interesting to test if some of these startups do need to rely on green-specific knowledge or if, instead, our result holds.

Notwithstanding the limits intrinsic to our analysis, we believe our results bear essential implications. Theory-wise, our proposition to include demand-side factors directly into the KSTE domain significantly enlarges the scope of the theory and helps explain what factors help enable knowledge spillover exploitation (Morris et al., 2024; Qian, 2018). The implications of adding the demand side to the KSTE are not limited to new startups but could also involve those large companies that generate a significant share of the local knowledge stock and its spillovers. Green demand, in fact, creates business opportunities for both large firms and startups. While large firms may struggle to adapt quickly to this new demand due to inertia, shortsightedness, or slower decision-making processes, startups can step in quickly to capture this demand with innovative solutions. As large companies attempt to respond to growing green demand, they require adapting specific technologies and processes, which startups are uniquely positioned to provide. Consequently, other than the direct and indirect effects described and tested in this paper within the classical KSTE framework, rising green demand indirectly supports green innovative startups through a derived demand for their technological solutions exerted by large firms. Our work cannot disentangle the two indirect effects arising from green demand (lessening the KF and inducing derived demand), but we hope that future research will look deeper at the interplay between large companies and startups in responding to new demand pressures.

Policy-wise, our results show that environmentally sustainable behaviours instantiating green demand foster green entrepreneurship; hence, sustainable mobility and waste and pollution management could be promoted in their own right and as factors that trigger effects on green entrepreneurship. Such regional and local policies can be a crucial pillar of entrepreneurial ecosystems (Morris et al., 2024). Moreover, our results suggest that rather than targeting specific environmental technologies, policymakers could more effectively promote entrepreneurship if they supported R&D and knowledge development in general, allowing the inherently unpredictable patterns of innovation to unfold.

Declaration of interest statement

No conflict of interest

References

Abdesselam, R., Kedjar, M., & Renou-Maissant, P. (2024). What are the drivers of eco-innovation? Empirical evidence from French start-ups. *Technological Forecasting and Social Change*, *198*, 122953. https://doi.org/10.1016/j.techfore.2023.122953

Acs, Z. J., Audretsch, D. B., Braunerhjelm, P., & Carlsson, B. (2004). The Missing Link: The Knowledge Filter and Entrepreneurship in Endogenous Growth. *CEPR Discussion Papers 4783*.

Acs, Z. J., Audretsch, D. B., & Feldman, M. P. (1994). R & D spillovers and recipient firm size. *The Review of Economics and Statistics*, 336–340.

Acs, Z. J., Braunerhjelm, P., Audretsch, D. B., & Carlsson, B. (2009). The knowledge spillover theory of entrepreneurship. *Small Business Economics*, *32*(1), 15–30. https://doi.org/10.1007/s11187-008-9157-3

Afifi, A., May, S., Donatello, R. A., & Clark, V. A. (2019). *Practical Multivariate Analysis* (6th ed.). Chapman and Hall/CRC. https://doi.org/10.1201/9781315203737

Ai, C., & Norton, E. C. (2003). Interaction terms in logit and probit models. *Economics Letters*, *80*(1), 123–129. https://doi.org/10.1016/S0165-1765(03)00032-6

Akcigit, U., & Van Reenen, J. (Eds.). (2023). *The economics of creative destruction: New research on themes from Aghion and Howitt*. Harvard University Press.

Alesina, A., Harnoss, J., & Rapoport, H. (2016). Birthplace diversity and economic prosperity. *Journal of Economic Growth*, *21*(2), 101–138. https://doi.org/10.1007/s10887-016-9127-6

Amoroso, S., Audretsch, D. B., & Link, A. N. (2018). Sources of knowledge used by entrepreneurial firms in the European high-tech sector. *Eurasian Business Review*, *8*(1), 55–70. https://doi.org/10.1007/s40821-017-0078-4

Antonelli, C. (2013). Knowledge governance: Pecuniary knowledge externalities and total factor productivity growth. *Economic Development Quarterly*, *27*(1), 62–70.

Antonelli, C., Crespi, F., Mongeau Ospina, C. A., & Scellato, G. (2017). Knowledge composition, Jacobs externalities and innovation performance in European regions. *Regional Studies*, *51*(11), 1708–1720. https://doi.org/10.1080/00343404.2016.1217405

Antonelli, C., Crespi, F., & Quatraro, F. (2022). Knowledge complexity and the mechanisms of knowledge generation and exploitation: The European evidence. *Research Policy*, *51*(8), 104081. https://doi.org/10.1016/j.respol.2020.104081

Armington, C., & Acs, Z. J. (2002). The Determinants of Regional Variation in New Firm Formation. *Regional Studies*, *36*(1), 33–45. https://doi.org/10.1080/00343400120099843

Audretsch, D. B., & Belitski, M. (2020). The role of R&D and knowledge spillovers in innovation and productivity. *European Economic Review*, *123*, 103391. https://doi.org/10.1016/j.euroecorev.2020.103391

Audretsch, D. B., Belitski, M., & Caiazza, R. (2021). Start-ups, Innovation and Knowledge Spillovers. *The Journal of Technology Transfer*, *46*(6), 1995–2016. https://doi.org/10.1007/s10961-021-09846-5

Audretsch, D. B., Bozeman, B., Combs, K. L., Feldman, M., Link, A. N., Siegel, D. S., Stephan, P., Tassey, G., & Wessner, C. (2002). The Economics of Science and Technology. *The Journal of Technology Transfer*, *27*(2), 155–203. https://doi.org/10.1023/A:1014382532639

Audretsch, D. B., Colombelli, A., Grilli, L., Minola, T., & Rasmussen, E. (2020). Innovative start-ups and policy initiatives. *Research Policy*, *49*(10), 104027. https://doi.org/10.1016/j.respol.2020.104027

Audretsch, D. B., & Keilbach, M. (2007). The Theory of Knowledge Spillover Entrepreneurship. *Journal of Management Studies*, *44*(7).

Audretsch, D. B., Lehemann, E. E., & Hinger, J. (2015). From knowledge to innovation: The role of knowledge spillover entrepreneurship. In *Routledge Handbook of the Economics of Knowledge*.

Audretsch, D. B., Obschonka, M., Gosling, S. D., & Potter, J. (2017). A new perspective on entrepreneurial regions: Linking cultural identity with latent and manifest entrepreneurship. *Small Business Economics*, *48*(3), 681–697. https://doi.org/10.1007/s11187-016-9787-9

Autio, E., Kenney, M., Mustar, P., Siegel, D., & Wright, M. (2014). Entrepreneurial innovation: The importance of context. *Research Policy*, *43*(7), 1097–1108. https://doi.org/10.1016/j.respol.2014.01.015

Barbieri, N., Marzucchi, A., & Rizzo, U. (2020). Knowledge sources and impacts on subsequent inventions: Do green technologies differ from non-green ones? *Research Policy*, *49*(2), 103901. https://doi.org/10.1016/j.respol.2019.103901

Barbieri, N., Marzucchi, A., & Rizzo, U. (2023). Green technologies, interdependencies, and policy. *Journal of Environmental Economics and Management*, *118*, 102791. https://doi.org/10.1016/j.jeem.2023.102791

Bellemare, M. F., Masaki, T., & Pepinsky, T. B. (2017). Lagged Explanatory Variables and the Estimation of Causal Effect. *The Journal of Politics*, *79*(3), 949–963. https://doi.org/10.1086/690946

Bonaccorsi, A., Colombo, M. G., Guerini, M., & Rossi-Lamastra, C. (2013). University specialization and new firm creation across industries. *Small Business Economics*, *41*(4), 837–863. https://doi.org/10.1007/s11187-013-9509-5

Bonfanti, A., De Crescenzo, V., Simeoni, F., & Loza Adaui, C. R. (2024). Convergences and divergences in sustainable entrepreneurship and social entrepreneurship research: A systematic review and research agenda. *Journal of Business Research*, *170*, 114336. https://doi.org/10.1016/j.jbusres.2023.114336

Brouhle, K., & Khanna, M. (2012). Determinants of participation versus consumption in the Nordic Swan eco-labeled market. *Ecological Economics*, *73*, 142–151. https://doi.org/10.1016/j.ecolecon.2011.10.011

Caiazza, R., Belitski, M., & Audretsch, D. B. (2020). From latent to emergent entrepreneurship: The knowledge spillover construction circle. *The Journal of Technology Transfer*, *45*(3), 694–704. https://doi.org/10.1007/s10961-019-09719-y

Cameron, A., & Miller, D. L. (2015). A Practitioner's Guide to Cluster-Robust Inference. *Journal of Human Resources*, *50*(2), 317–372. https://doi.org/10.3368/jhr.50.2.317

Caravella, S., & Crespi, F. (2021). The role of public procurement as innovation lever: Evidence from Italian manufacturing firms. *Economics of Innovation and New Technology*, *30*(7), 663–684. https://doi.org/10.1080/10438599.2020.1761591

Carree, M., & Thurik, R. (1996). Entry and Exit in Retailing: Incentives, Barriers, Displacement and Replacement. *Review of Industrial Organization*, *11*(2), 155–172.

Chapman, G., & Hottenrott, H. (2022). Green start-ups and the role of founder personality. *Journal of Business Venturing Insights*, *17*, e00316. https://doi.org/10.1016/j.jbvi.2022.e00316

Cillo, V., Petruzzelli, A. M., Ardito, L., & Del Giudice, M. (2019). Understanding sustainable innovation: A systematic literature review. *Corporate Social Responsibility and Environmental Management*, *26*(5), 1012–1025. https://doi.org/10.1002/csr.1783

Cohen, B., & Winn, M. I. (2007). Market imperfections, opportunity and sustainable entrepreneurship. *Journal of Business Venturing*, *22*(1), 29–49. https://doi.org/10.1016/j.jbusvent.2004.12.001

Cojoianu, T. F., Clark, G. L., Hoepner, A. G. F., Veneri, P., & Wójcik, D. (2020). Entrepreneurs for a low carbon world: How environmental knowledge and policy shape the creation and financing of green start-ups. *Research Policy*, *49*(6), 103988. https://doi.org/10.1016/j.respol.2020.103988

Coll-Martínez, E., Kedjar, M., & Renou-Maissant, P. (2022). (Green) Knowledge spillovers and regional environmental support: Do they matter for the entry of new green tech-based firms? *The Annals of Regional Science*, *69*(1), 119–161. https://doi.org/10.1007/s00168-022-01111-3

Colombelli, A., D'Ambrosio, A., & Ravetti, C. (2024). Women in innovative start-ups and regional inclusiveness: 'Green' and socially-responsible companies. *Regional Studies*, 1–14. https://doi.org/10.1080/00343404.2024.2340999

Colombelli, A., D'Amico, E., & Paolucci, E. (2023). When computer science is not enough: Universities knowledge specializations behind artificial intelligence startups in Italy. *The Journal of Technology Transfer*, *48*(5), 1599–1627. https://doi.org/10.1007/s10961-023-10029-7

Colombelli, A., Krafft, J., & Vivarelli, M. (2016). To be born is not enough: The key role of innovative start-ups. *Small Business Economics*, *47*(2), 277–291. https://doi.org/10.1007/s11187-016-9716-y

Colombelli, A., & Quatraro, F. (2018). New firm formation and regional knowledge production modes: Italian evidence. *Research Policy*, *47*(1), 139–157. https://doi.org/10.1016/j.respol.2017.10.006

Colombelli, A., & Quatraro, F. (2019). Green start-ups and local knowledge spillovers from clean and dirty technologies. *Small Business Economics*, *52*(4), 773–792. https://doi.org/10.1007/s11187-017-9934-y

Corradini, C. (2019). Location determinants of green technological entry: Evidence from European regions. *Small Business Economics*, *52*(4), 845–858. https://doi.org/10.1007/s11187-017-9938-7

Costantini, V., Crespi, F., Martini, C., & Pennacchio, L. (2015). Demand-pull and technology-push public support for eco-innovation: The case of the biofuels sector. *Research Policy*, *44*(3), 577–595. https://doi.org/10.1016/j.respol.2014.12.011

D'Ambrosio, A., Gabriele, R., Schiavone, F., & Villasalero, M. (2017). The role of openness in explaining innovation performance in a regional context. *The Journal of Technology Transfer*, *42*(2), 389–408. https://doi.org/10.1007/s10961-016-9501-8

De Marchi, V. (2012). Environmental innovation and R&D cooperation: Empirical evidence from Spanish manufacturing firms. *Research Policy*, *41*(3), 614–623. https://doi.org/10.1016/j.respol.2011.10.002

Dechezlepretre, A., Martin, R., & Mohnen, M. (2017). *Knowledge Spillovers from clean and dirty technologies*. GRI Working Papers 135, Grantham Research Institute on Climate Change and the Environment.

Del Río, P., Peñasco, C., & Romero-Jordán, D. (2016). What drives eco-innovators? A critical review of the empirical literature based on econometric methods. *Journal of Cleaner Production*, *112*, 2158–2170. https://doi.org/10.1016/j.jclepro.2015.09.009

Di Stefano, G., Gambardella, A., & Verona, G. (2012). Technology push and demand pull perspectives in innovation studies: Current findings and future research directions. *Research Policy*, *41*(8), 1283–1295. https://doi.org/10.1016/j.respol.2012.03.021

Dong, S., Gong, H., & Liu, T. (2022). Environmental technology spillovers and green start-up emergence: The moderating role of patent commercialization policy and patent enforcement. *Environmental Science and Pollution Research*, *29*(46), 70070–70083. https://doi.org/10.1007/s11356-022-20791-0

Farrow, K., Grolleau, G., & Ibanez, L. (2017). Social Norms and Pro-environmental Behavior: A Review of the Evidence. *Ecological Economics*, *140*, 1–13. https://doi.org/10.1016/j.ecolecon.2017.04.017

Fichter, K., Lüdeke-Freund, F., Schaltegger, S., & Schillebeeckx, S. J. D. (2023). Sustainability impact assessment of new ventures: An emerging field of research. *Journal of Cleaner Production*, *384*, 135452. https://doi.org/10.1016/j.jclepro.2022.135452

Frenken, K., Van Oort, F., & Verburg, T. (2007). Related Variety, Unrelated Variety and Regional Economic Growth. *Regional Studies*, *41*(5), 685–697. https://doi.org/10.1080/00343400601120296

Fritsch, M., & Falck, O. (2007). New Business Formation by Industry over Space and Time: A Multidimensional Analysis. *Regional Studies*, *41*(2), 157–172. https://doi.org/10.1080/00343400600928301
Fusillo, F. (2023). Green Technologies and diversity in the knowledge search and output phases: Evidence from European Patents. *Research Policy*, *52*(4), 104727. https://doi.org/10.1016/j.respol.2023.104727
Fusillo, F., Quatraro, F., & Usai, S. (2022). Going green: The dynamics of green technological alliances. *Economics of Innovation and New Technology*, *31*(5), 362–386. https://doi.org/10.1080/10438599.2020.1799143
Gast, J., Gundolf, K., & Cesinger, B. (2017). Doing business in a green way: A systematic review of the ecological sustainability entrepreneurship literature and future research directions. *Journal of Cleaner Production*, *147*, 44–56. https://doi.org/10.1016/j.jclepro.2017.01.065
Gebhardt, L., & Bachmann, N. (2023). Entrepreneurial contributions to sustainability transitions—A longitudinal study of their representation and enactment through topic modeling and thematic analysis. *Journal of Cleaner Production*, *420*, 138255. https://doi.org/10.1016/j.jclepro.2023.138255
Gidron, B., Bar, K., Finger Keren, M., Gafni, D., Hodara, Y., Krasnopolskaya, I., & Mannor, A. (2023). The Impact Tech Startup: Initial Findings on a New, SDG-Focused Organizational Category. *Sustainability*, *15*(16), 12419. https://doi.org/10.3390/su151612419
Giudici, G., Guerini, M., & Rossi-Lamastra, C. (2019). The creation of cleantech startups at the local level: The role of knowledge availability and environmental awareness. *Small Business Economics*, *52*(4), 815–830. https://doi.org/10.1007/s11187-017-9936-9
Gorovaia, N., & Makrominas, M. (2024). Identifying greenwashing in corporate-social responsibility reports using natural-language processing. *European Financial Management*, eufm.12509. https://doi.org/10.1111/eufm.12509
Greene, W. H. (2003). *Econometric analysis* (5th Edition). Prentice Hall.
Grootendorst, M. (2022). *BERTopic: Neural topic modeling with a class-based TF-IDF procedure* (Version 1). arXiv. https://doi.org/10.48550/ARXIV.2203.05794
Hall, B. H., Griliches, Z., & Hausman, J. A. (1986). Patents and R and D: Is There a Lag? *International Economic Review*, *27*(2), 265. https://doi.org/10.2307/2526504
Hall, B. H., Jaffe, A., & Trajtenberg, M. (2005). Market Value And Patent Citations. *Rand Journal of Economics*, *36*(1), 16–38.
Hausman, J., Hall, B. H., & Griliches, Z. (1984). Econometric Models for Count Data with an Application to the Patents-R & D Relationship. *Econometrica*, *52*(4), 909. https://doi.org/10.2307/1911191
Haws, K. L., Winterich, K. P., & Naylor, R. W. (2014). Seeing the world through GREEN-tinted glasses: Green consumption values and responses to environmentally friendly products. *Journal of Consumer Psychology*, *24*(3), 336–354. https://doi.org/10.1016/j.jcps.2013.11.002
Hoogendoorn, B., Van Der Zwan, P., & Thurik, R. (2020). Goal heterogeneity at start-up: Are greener start-ups more innovative? *Research Policy*, *49*(10), 104061. https://doi.org/10.1016/j.respol.2020.104061
Horbach, J., Oltra, V., & Belin, J. (2013). Determinants and Specificities of Eco-Innovations Compared to Other Innovations—An Econometric Analysis for the French and German Industry Based on the Community Innovation Survey. *Industry & Innovation*, *20*(6), 523–543. https://doi.org/10.1080/13662716.2013.833375
Hörisch, J. (2015). Crowdfunding for environmental ventures: An empirical analysis of the influence of environmental orientation on the success of crowdfunding initiatives. *Journal of Cleaner Production*, *107*, 636–645. https://doi.org/10.1016/j.jclepro.2015.05.046
Horne, J., & Fichter, K. (2022). Growing for sustainability: Enablers for the growth of impact startups – A conceptual framework, taxonomy, and systematic literature review. *Journal of Cleaner Production*, *349*, 131163. https://doi.org/10.1016/j.jclepro.2022.131163

Horne, J., Recker, M., Michelfelder, I., Jay, J., & Kratzer, J. (2020). Exploring entrepreneurship related to the sustainable development goals—Mapping new venture activities with semi-automated content analysis. *Journal of Cleaner Production*, *242*, 118052. https://doi.org/10.1016/j.jclepro.2019.118052

Jha, V. K., & Pande, A. S. (2024). Making sustainable development happen: Does sustainable entrepreneurship make nations more sustainable? *Journal of Cleaner Production*, *440*, 140849. https://doi.org/10.1016/j.jclepro.2024.140849

Joshi, Y., & Rahman, Z. (2015). Factors Affecting Green Purchase Behaviour and Future Research Directions. *International Strategic Management Review*, *3*(1–2), 128–143. https://doi.org/10.1016/j.ism.2015.04.001

Kalcheva, I., McLemore, P., & Pant, S. (2018). Innovation: The interplay between demand-side shock and supply-side environment. *Research Policy*, *47*(2), 440–461. https://doi.org/10.1016/j.respol.2017.11.011

Kesidou, E., & Demirel, P. (2012). On the drivers of eco-innovations: Empirical evidence from the UK. *Research Policy*, *41*(5), 862–870. https://doi.org/10.1016/j.respol.2012.01.005

Koellinger, P. (2008). Why are some entrepreneurs more innovative than others? *Small Business Economics*, *31*(1), 21–37. https://doi.org/10.1007/s11187-008-9107-0

Kuckertz, A., Berger, E. S. C., & Gaudig, A. (2019). Responding to the greatest challenges? Value creation in ecological startups. *Journal of Cleaner Production*, *230*, 1138–1147. https://doi.org/10.1016/j.jclepro.2019.05.149

Laursen, K., & Salter, A. (2006). Open for innovation: The role of openness in explaining innovation performance among U.K. manufacturing firms. *Strategic Management Journal*, *27*(2), 131–150. https://doi.org/10.1002/smj.507

Lee, S. S., Kim, Y., & Roh, T. (2023). Pro-environmental behavior on electric vehicle use intention: Integrating value-belief-norm theory and theory of planned behavior. *Journal of Cleaner Production*, *418*, 138211. https://doi.org/10.1016/j.jclepro.2023.138211

Li, Z., Shang, W., & Yan, M. (2016). News text classification model based on topic model. *2016 IEEE/ACIS 15th International Conference on Computer and Information Science (ICIS)*, 1–5. https://doi.org/10.1109/ICIS.2016.7550929

Messeni Petruzzelli, A., Maria Dangelico, R., Rotolo, D., & Albino, V. (2011). Organizational factors and technological features in the development of green innovations: Evidence from patent analysis. *Innovation*, *13*(3), 291–310. https://doi.org/10.5172/impp.2011.13.3.291

Mio, C., Panfilo, S., & Blundo, B. (2020). Sustainable development goals and the strategic role of business: A systematic literature review. *Business Strategy and the Environment*, *29*(8), 3220–3245. https://doi.org/10.1002/bse.2568

Mize, T. (2019). Best Practices for Estimating, Interpreting, and Presenting Nonlinear Interaction Effects. *Sociological Science*, *6*, 81–117. https://doi.org/10.15195/v6.a4

Mokyr, J. (2011). *The Gifts of Athena: Historical Origins of the Knowledge Economy*. Princeton University Press.

Montgomery, A. W., Lyon, T. P., & Barg, J. (2023). No End in Sight? A Greenwash Review and Research Agenda. *Organization & Environment*, 108602662311689. https://doi.org/10.1177/10860266231168905

Morris, A. K., Fiedler, A., & Audretsch, D. B. (2024). Enablers of knowledge spillover entrepreneurship in entrepreneurial ecosystems: Synthesis and future directions. *The Journal of Technology Transfer*, *49*(5), 1737–1761. https://doi.org/10.1007/s10961-023-10056-4

Mrkajic, B., Murtinu, S., & Scalera, V. G. (2019). Is green the new gold? Venture capital and green entrepreneurship. *Small Business Economics*, *52*(4), 929–950. https://doi.org/10.1007/s11187-017-9943-x

Nguyen, T. N., Lobo, A., & Greenland, S. (2016). Pro-environmental purchase behaviour: The role of consumers' biospheric values. *Journal of Retailing and Consumer Services*, *33*, 98–108. https://doi.org/10.1016/j.jretconser.2016.08.010

Nomaler, Ö., & Verspagen, B. (2019). Greentech homophily and path dependence in a large patent citation network. *UNU-MERIT Working Papers*, *#2019-051*.
Orsatti, G. (2024). Government R&D and green technology spillovers: The Chernobyl disaster as a natural experiment. *The Journal of Technology Transfer*, *49*(2), 581–608. https://doi.org/10.1007/s10961-023-10000-6
Orsatti, G., Quatraro, F., & Pezzoni, M. (2020). The antecedents of green technologies: The role of team-level recombinant capabilities. *Research Policy*, *49*(3), 103919. https://doi.org/10.1016/j.respol.2019.103919
Orsatti, G., Quatraro, F., & Scandura, A. (2024). Green technological diversification and regional recombinant capabilities: The role of technological novelty and academic inventors. *Regional Studies*, *58*(1), 120–134. https://doi.org/10.1080/00343404.2023.2176476
Paul, J., Modi, A., & Patel, J. (2016). Predicting green product consumption using theory of planned behavior and reasoned action. *Journal of Retailing and Consumer Services*, *29*, 123–134. https://doi.org/10.1016/j.jretconser.2015.11.006
Polanyi, M. (1966). The Logic of Tacit Inference. *Philosophy*, *41*(155), 1–18.
Purvis, B., Mao, Y., & Robinson, D. (2019). Three pillars of sustainability: In search of conceptual origins. *Sustainability Science*, *14*(3), 681–695. https://doi.org/10.1007/s11625-018-0627-5
Qian, H. (2018). Knowledge-Based Regional Economic Development: A Synthetic Review of Knowledge Spillovers, Entrepreneurship, and Entrepreneurial Ecosystems. *Economic Development Quarterly*, *32*(2), 163–176. https://doi.org/10.1177/0891242418760981
Qian, H., & Jung, H. (2017). Solving the knowledge filter puzzle: Absorptive capacity, entrepreneurship and regional development. *Small Business Economics*, *48*(1), 99–114. https://doi.org/10.1007/s11187-016-9769-y
Quatraro, F., & Scandura, A. (2019). Academic Inventors and the Antecedents of Green Technologies. A Regional Analysis of Italian Patent Data. *Ecological Economics*, *156*, 247–263. https://doi.org/10.1016/j.ecolecon.2018.10.007
Rehfeld, K.-M., Rennings, K., & Ziegler, A. (2007). Integrated product policy and environmental product innovations: An empirical analysis. *Ecological Economics*, *61*(1), 91–100. https://doi.org/10.1016/j.ecolecon.2006.02.003
Reimers, N., & Gurevych, I. (2019). *Sentence-BERT: Sentence Embeddings using Siamese BERT-Networks* (Version 1). arXiv. https://doi.org/10.48550/ARXIV.1908.10084
Rennings, K. (2000). Redefining innovation—Eco-innovation research and the contribution from ecological economics. *Ecological Economics*, *32*(2), 319–332. https://doi.org/10.1016/S0921-8009(99)00112-3
Reynolds, P., Storey, D. J., & Westhead, P. (1994). Cross-national Comparisons of the Variation in New Firm Formation Rates. *Regional Studies*, *28*(4), 443–456. https://doi.org/10.1080/00343409412331348386
Roome, N., & Wijen, F. (2006). Stakeholder Power and Organizational Learning in Corporate Environmental Management. *Organization Studies*, *27*(2), 235–263. https://doi.org/10.1177/0170840605057669
Santoalha, A., & Boschma, R. (2021). Diversifying in green technologies in European regions: Does political support matter? *Regional Studies*, *55*(2), 182–195. https://doi.org/10.1080/00343404.2020.1744122
Saviotti, P. P. (1988). Information, variety and entropy in technoeconomic development. *Research Policy*, *17*(2), 89–103. https://doi.org/10.1016/0048-7333(88)90024-8
Schaltegger, S., & Wagner, M. (2011). Sustainable entrepreneurship and sustainability innovation: Categories and interactions. *Business Strategy and the Environment*, *20*(4), 222–237. https://doi.org/10.1002/bse.682
Schøtt, T., & Jensen, K. W. (2016). Firms' innovation benefiting from networking and institutional support: A global analysis of national and firm effects. *Research Policy*, *45*(6), 1233–1246. https://doi.org/10.1016/j.respol.2016.03.006

Shane, S. (2009). Why encouraging more people to become entrepreneurs is bad public policy. *Small Business Economics*, *33*(2), 141–149. https://doi.org/10.1007/s11187-009-9215-5

Shepherd, D. A., & Patzelt, H. (2011). The New Field of Sustainable Entrepreneurship: Studying Entrepreneurial Action Linking "What is to be Sustained" with "What is to be Developed". *Entrepreneurship Theory and Practice*, *35*(1), 137–163. https://doi.org/10.1111/j.1540-6520.2010.00426.x

Spigel, B. (2017). The Relational Organization of Entrepreneurial Ecosystems. *Entrepreneurship Theory and Practice*, *41*(1), 49–72. https://doi.org/10.1111/etap.12167

Stam, E. (2015). Entrepreneurial Ecosystems and Regional Policy: A Sympathetic Critique. *European Planning Studies*, *23*(9), 1759–1769. https://doi.org/10.1080/09654313.2015.1061484

Sutaria, V., & Hicks, D. A. (2004). New firm formation: Dynamics and determinants. *The Annals of Regional Science*, *38*(2), 241–262. https://doi.org/10.1007/s00168-004-0194-9

Tiba, S., Van Rijnsoever, F. J., & Hekkert, M. P. (2021). Sustainability startups and where to find them: Investigating the share of sustainability startups across entrepreneurial ecosystems and the causal drivers of differences. *Journal of Cleaner Production*, *306*, 127054. https://doi.org/10.1016/j.jclepro.2021.127054

Umamaheswaran, S., Dar, V., Sharma, E., & Kurian, J. S. (2023). Mapping Climate Themes From 2008-2021—An Analysis of Business News Using Topic Models. *IEEE Access*, *11*, 26554–26565. https://doi.org/10.1109/ACCESS.2023.3256530

UNEP. (2019). *Global Environment Outlook 6 (GEO6)*. United Nations Environment Programme. https://www.unep.org/resources/global-environment-outlook-6

Vedula, S., York, J. G., & Corbett, A. C. (2019). Through the Looking-Glass: The Impact of Regional Institutional Logics and Knowledge Pool Characteristics on Opportunity Recognition and Market Entry. *Journal of Management Studies*, *56*(7), 1414–1451. https://doi.org/10.1111/joms.12400

Wagner, J., & Sternberg, R. (2004). Start-up activities, individual characteristics, and the regional milieu: Lessons for entrepreneurship support policies from German micro data. *The Annals of Regional Science*, *38*(2), 219–240. https://doi.org/10.1007/s00168-004-0193-x

Wöhler, J., & Haase, E. (2022). Exploring investment processes between traditional venture capital investors and sustainable start-ups. *Journal of Cleaner Production*, *377*, 134318. https://doi.org/10.1016/j.jclepro.2022.134318

Wong, S. K. S. (2013). Environmental Requirements, Knowledge Sharing and Green Innovation: Empirical Evidence from the Electronics Industry in China. *Business Strategy and the Environment*, *22*(5), 321–338. https://doi.org/10.1002/bse.1746

York, J. G., Vedula, S., & Lenox, M. J. (2018). It's Not Easy Building Green: The Impact of Public Policy, Private Actors, and Regional Logics on Voluntary Standards Adoption. *Academy of Management Journal*, *61*(4), 1492–1523. https://doi.org/10.5465/amj.2015.0769

York, J. G., & Venkataraman, S. (2010). The entrepreneur–environment nexus: Uncertainty, innovation, and allocation. *Journal of Business Venturing*, *25*(5), 449–463. https://doi.org/10.1016/j.jbusvent.2009.07.007

Yun, J., & Geum, Y. (2020). Automated classification of patents: A topic modeling approach. *Computers & Industrial Engineering*, *147*, 106636. https://doi.org/10.1016/j.cie.2020.106636

Zeppini, P., & Van Den Bergh, J. C. J. M. (2011). Competing Recombinant Technologies for Environmental Innovation: Extending Arthur's Model of Lock-In. *Industry & Innovation*, *18*(3), 317–334. https://doi.org/10.1080/13662716.2011.561031

Zhang, F., & Zhu, L. (2019). Enhancing corporate sustainable development: Stakeholder pressures, organizational learning, and green innovation. *Business Strategy and the Environment*, *28*(6), 1012–1026. https://doi.org/10.1002/bse.2298